Nov. 18, 1969 J. A. VICTOREEN 3,478,840

SOUND REPRODUCER

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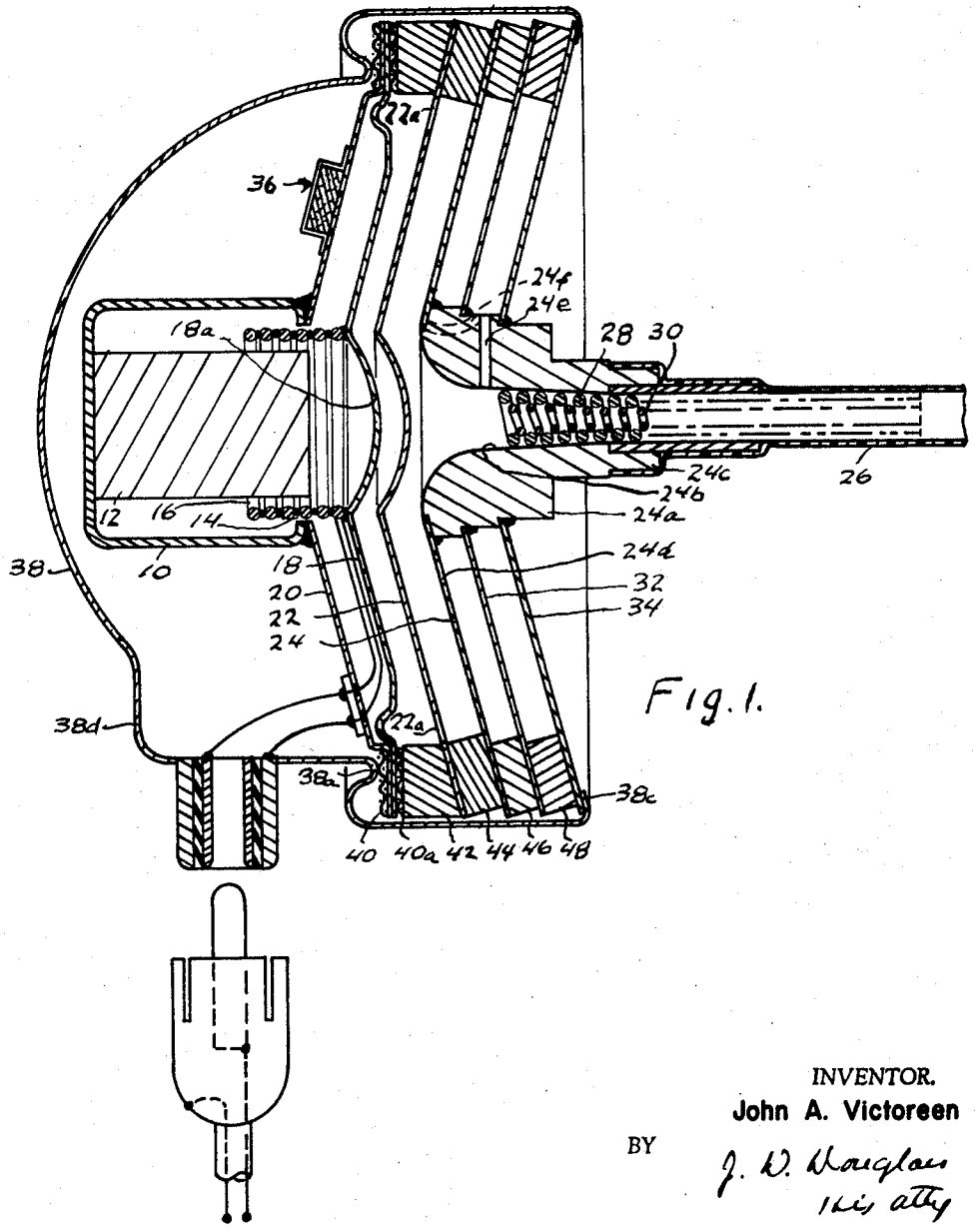


Fig. 1.

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SOUND REPRODUCER

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ABSTRACT OF THE DISCLOSURE

A reproducer which may be used for generating sound pressures for testing hearing or as a hearing aid which has a substantially flat response curve from 100 to 9000 cycles includes a diaphragm, vibrated by a voice coil, in front of which is a closely spaced rigid damping plate having sound passages at its periphery. Beyond the damping plate in spaced relation is a rigid manifold plate having a central sound outlet which may be connected to an ear or other place where the sound is to be utilized. Means is provided for eliminating the resonant peaks inherent in a diaphragm-type reproducer which includes controlling the sound pressure leakage to the rear of the cone, and providing chambers by additional plates in front of manifold plate which communicate with the chamber formed by the manifold and damping plate to reduce or eliminate resonant peaks.

This invention relates to sound pressure reproducers and more particularly to a precision reproducer having a substantially flat response characteristic over a frequency range from 100 to 9000 cycles or greater and which is particularly useful for the testing of hearing and other purposes.

One of the most difficult problems in the testing of hearing is to obtain a sound pressure reproducer which will not of itself distort the sounds or signals that are to be introduced to the ear canal. Known reproducers of even the most expensive type inherently have undesirable resonant peaks in the frequency response curve. This has introduced into the testing system a high complicated calibrating problem. In addition, heretofore the reproducers lacked uniformity in their output of sound pressures due to slight variations in the mechanical structure of the components which went to make up the composite structure, with the result that no two reproducers provided exactly or closely similar results.

By the present invention I am able to make reproducers the output of which may be made very closely similar to each other thus eliminating the need for highly skilled labor in the manufacture thereof and enabling such adjustment as is required to be easily and quickly made by persons of a minimum skill in the art.

Briefly, the invention contemplates a reproducer having a cone-type diaphragm with a voice coil operating in a magnetic field. In front of the cone is a rigid, nonmovable damping plate of substantially same conformation as the cone, which adds to the mechanical stiffness of the cone. Sound pressures generated by movement of the cone diaphragm are allowed to escape at the edge of the effective part of the damping plate into a collecting or manifold chamber which consists of a similar rigid, generally conical plate in spaced relation from the manifold plate. The center of this last plate is provided with a sound outlet duct which may be connected to the point of utilization.

Still other advantages of the invention and the invention itself will become apparent from the following description of an embodiment thereof, which is illustrated by the accompanying drawing, and forms a part of this specification.

In the drawing:

FIG. 1 is a sectional view of the invention.

As shown in the drawing, there is provided the usual field pole frame **10** which mounts a permanent magnet **12**, the end of the magnet and the field pole frame forming an annular air gap **14**. A voice coil **16** is disposed in the air gap, being attached to a generally conical cone diaphragm **18**, which in turn is supported by a cone support **20** attached at its inner end to the field frame and supported at its outer edge, as later described, along with the cone diaphragm. The cone diaphragm **18** is generally conical except for a stiffened, generally semi-spherical portion **18***a*. Adjacent the outer extremity is a flexible region which permits the diaphragm to move. Hereinafter the diaphragm will be termed a cone or a diaphragm inasmuch as the area of the central portion, which is not conical, is minimal.

Forwardly of the cone diaphragm and in closely spaced relation is a stiff, immovable damping plate **22** of the same general conformation as the cone which has a mechanical stiffening affect upon the cone. The extreme outer portion of the damping plate is clamped. Immediately inwardly of the place where it is clamped, it is provided with a series of sound pressure releasing apertures **22***a* around its periphery. The apertures may be of the order of ⅛" diameter but may vary in size.

Forwardly of the damping plate there is provided a collecting or manifold chamber by means of another conical plate **24**, also clamped at its periphery, and the center of which is provided with a coupling hub **24***a* formed with an axial sound outlet opening **24***b*. The forward extremity of the hub may be provided with a tubular extension **24***c* for attachment to a coupling means. The shape of the opening **24***b* in the hub may vary. It may be a cylindrical opening or funnel shaped with the wide portion opening toward the damping plate or a series of cylinders of gradually reduced diameter with the largest towards the damping plate, or a formation which may be considered exponential. A sound conducting tube **26** may be connected to the hub coupling **24***a* in any suitable manner, such as by telescoping over the extension **24***c*. The tube **26** may be connected to a suitable load which may be an ear mold, when hearing is testing, or to a standard 2CC coupler for calibration purposes.

The sound outlet tube may be provided with an element which acts as an acoustical resistance and also as a reinforcement for the tube, which is usually flexible, to maintain its shape. This may be in the form of a helical or conical coil, telescoped within the tube which, in the case of the tube of varying diameter, will be formed of a helical wire **28**, the convolutions of which are closely adjacent to each other and the diameter of which is about the same as that of the inner wall of the tube. Inwardly of this coil may be a second coil **30** of similar shape to provide additional acoustical resistance when required. These likewise may be changed depending upon the demands of the instrument.

The above constitutes the basic form of the invention. It will be appreciated that dimensions will be determined by the type and kind of load to which the device is being applied and may vary greatly from that shown in the drawing, which is a highly enlarged view with the spacings between the elements exaggerated in the interest of clarity of description.

As previously pointed out, the cone diaphragm **18** moves as a piston. The damping plate does not move and should be close enough to the cone to provide air compression in front of the diaphragm, raising the high frequency limits of the device. The collecting chamber defined by the damping plate and the manifold plate is

the means whereby the sound that passes through the apertures **22***a* moves radially of the manifold plate toward and combines at the center. This space may alternatively consist of a series of radial channels joining the peripheral holes **22***a* with the center outlet **24***b*.

A further refinement of the invention resides in the means that are provided for reducing or eliminating peaks in the response curve to provide a substantially flat sound pressure output with variable frequency. It can be assumed, and is usually a fact, that there is a major peak response near the low frequency end, at about 250 cycles, and another peak at about 1500 cycles, which must be suppressed. This suppression is effected largely by additional chambers in front of the manifold plate which communicates with the sound collecting chamber and act as anti-resonant devices operating at the frequency of the peaks to be suppressed. A natural characteristic of a device of this character is to provide too much sound pressure at low frequencies. In front of the manifold there is provided a first chamber plate **32**, also of rigid conical formation, which may be rigidly secured to the hub **24***a* in any suitable manner. Likewise the outer rim of this plate is rigidly clamped. One or more openings **24***d* are provided in the manifold plate communicating with this chamber which may be located close to the hub but may vary in their location. The acoustical reactance of the air within the holes and the volume of air within the chamber combine to determine the resonant frequency of the chamber which reduces the amplitude of the second peak previously described (approximately 1500 cycles).

Forwardly of the first chamber is a second chamber formed by a conical plate **34**, also secured or sealed to the hub and clamped at its outer edge. Sound pressures from the collecting chamber may enter this chamber through a duct **24***e* or **24***f*, indicated in dotted lines. This chamber operates in a manner similar to the first chamber but is effective in reducing the first peak (approximately 250 cycles). It is essential that the volume of the chamber and the acoustical resistance associated therewith be designed to provide the proper amount of suppression at the desired frequency. Additional acoustical resistance may be required in the form of acoustical material disposed in the chambers.

The usual rear acoustical damper **36** comprises pieces of fibrous material disposed over holes in the rear of the cone support.

The general high amplitude response at the low frequency end of the curve is reduced by venting the compression chamber, defined by the cone and damping plate, to the rear of the cone support through an element which is essentially an acoustical resistance. This consists of a pair of wire mesh screen rings **40** and **40***a* disposed on opposite sides of the cone flange and the cone support flange which are in contact with each other. These are clamped by flanges on the casing **38**, the body of which is substantially semi-spherical. The casing is provided with a reversely curved portion **38***a* at its periphery which engages with the screen **40**. A cylindrical flange **38***b* extends along the outer side of the assembly and is spun over at its outer edge as at **38***c*. The spacing of the cones from each other is effected by metal rings, the first of which, **42**, is of trapezoidal cross-section to provide a frusto-conical seat for the edge of the damping plate **22** and is disposed between the plate **22** and the cone **18**. Likewise rings **44**, **46** and **48** of rectangular cross-section may be placed between the damping plate **22** and manifold plate **24**, between the manifold plate **24** and first chamber plate **32**, and between the first chamber plate **32** and the second chamber plate **34**. It is pointed out that the damping, manifold and chamber plates are generally conical throughout their entire cross section to their edge, which will provide maximum rigidity therefor. The spinning of the end flange **38***c* of the casing over the assembly, together with the reversely curved part **38***a* which forms a bead projecting toward the screen **40**, provides a resilient clamping which maintains residual tension on the parts after the device is assembled.

The cones **32** and **34**, being rigidly secured to the hub **24***a* and being supported at their outermost edges, furnish additional rigid support for the manifold plate **24**.

At one side the casing is provided with a boss **38***d* in which there is disposed an electrical connector **50** which is connected by wires to the voice coil and may also provide a back vent for static pressure.

It is particularly pointed out that the device as constructed has no planar surfaces, all surfaces being so constructed as to increase the stiffness and minimize any possible inherent vibration.

It will also be noted that the construction is such that there is always a venting from the outlet tube through the assembly toward the rear and that therefore the attachment of the device to a standard coupler, or any other device, will provide a static pressure equalizing thereof.

Having thus described the invention in an embodiment thereof, I am aware that numerous and extensive departures may be made therefrom without departing from the spirit or scope of the invention as defined by the appended claims.

I claim:

1. A precision sound pressure generator including a movable diaphragm having a substantially conical surface with a flexible supporting edge, a substantially immovable rigid damping plate of essentially the same conformation as the diaphragm and closely spaced thereto and formed to provide for sound pressure egress closely adjacent the periphery thereof, a second substantially immovable rigid plate disposed in spaced relation to said damping plate and formed to provide an axial sound pressure outlet opening.

2. A pressure generator as described in claim **1**, wherein a sound pressure duct is provided at said outlet opening and said duct is provided with an acoustical resistance.

3. A pressure generator as described in claim **1** wherein the space between the damping plate and said second plate is provided with an acoustical resistance therein.

4. A pressure generator as described in claim **3**, wherein a sound pressure duct is provided at said outlet opening and said duct is provided with an acoustical resistance.

5. A pressure generator as described in claim **1**, wherein a sound pressure duct is provided at said outlet opening having a cross-section which varies in diameter with length to provide predetermined acoustical impedance properties.

6. A pressure generator as described in claim **5**, wherein said sound pressure duct is exponential or horned shape in form.

7. A pressure generator as described in claim **6**, wherein the cross sectional area decreases in area toward the outlet of the duct.

8. A pressure generator as described in claim **7**, wherein said duct is provided with an acoustical resistance.

9. A pressure generator as described in claim **1**, wherein a third substantially immovable rigid plate is disposed in spaced relation to said second plate and an acoustical entrance from the system is provided to the space between the damping plate and the second plate to provide an acoustically resonant chamber for the purpose of suppressing one of the resonant peaks comprising the frequency response of the device.

10. A pressure generator as described in claim **9**, wherein said third plate is substantially conical to its outer edge.

11. A pressure generator as described in claim 9, wherein a fourth substantially immovable rigid plate is disposed in spaced relation to said third plate and an acoustical entrance from the system is provided to comprise a second acoustically resonant chamber for the purpose of suppressing another of the resonant peaks comprising the frequency response of the device.

12. The pressure generator as described in claim 11, wherein said fourth plate is substantially conical to its outer edge.

13. A pressure generator as described in claim 1, wherein at least one acoustically resonant chamber is connected to communicate with the space between the damping plate and the second plate to provide at least one acoustically resonant chamber for the purpose of suppressing one or more of the resonant peaks comprising the frequency response of the device.

14. A pressure generator as described in claim 1, wherein a casing free from planar surfaces surrounds said generator and has a peripheral portion secured in clamping relation to said diaphragm and said plate.

15. A pressure generator as described in claim 14, wherein means is provided at the edge of said diaphragm to provide passage of sound pressures around the edge of said diaphragm to the space in said casing to provide acoustical resistance and reactance and suppress the low frequency response of said device.

16. A pressure generator as described in claim 15, wherein said diaphragm is supported by a cone support at its outer edge and said means comprises a pair of rings of wire mesh or other acoustically transmitting material on opposite sides of the edges of said cone support and said diaphragm.

17. A pressure generator as described in claim 1, wherein the conical formation of the damping plate extends to the outer edge and wherein a center portion is substantially semi-spherical.

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